(12) UK Patent Application (19) GB (11) 2 399 466 (13) A

(43) Date of A Publication 15.09.2004

(21) Application No: 0305428.5

(22) Date of Filing: 10.03.2003

(71) Applicant(s):
City University of Hong Kong
(Incorporated In Hong Kong)
Tat Chee Avenue, Kowloon Tong,
Kowloon, Hong Kong

(72) Inventor(s):
Shu-Yuen Ron Hui

(74) Agent and/or Address for Service:
Lloyd Wise
Commonwealth House,
1-19 New Oxford Street, LONDON,
WC1A 1LW, United Kingdom

(51) INT CL[7]:
H02J 7/02

(52) UK CL (Edition W):
H2H HAM HBCH

(56) Documents Cited:
US 5959433 A

(58) Field of Search:
UK CL (Edition V) H2H
INT CL[7] H02J
Other: Online: WPI, PAJ, EPODOC

(54) Abstract Title: **Battery charging system**

(57) A battery charging system is disclosed that comprises a primary module and at least one secondary module (20). The primary module comprises means (13) for connecting to a mains supply, and at least one primary winding (6, 15, 16) adjacent a charging surface (4) of the primary module. The secondary module (20) comprises a secondary winding (24) adjacent a surface of said secondary module, circuit means (25) for converting alternating current generated in said secondary winding (24) to a regulated DC output, and a charging connector (22) for connection to the charging socket of an electronic device. The system is suitable for mobile phones, MP3 players, and hand-held computers.

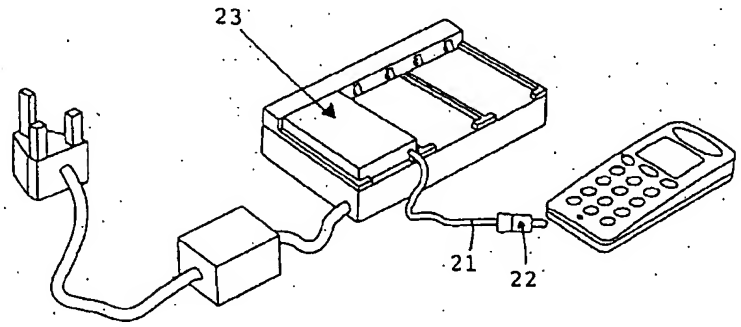

FIG. 12

GB 2 399 466 A

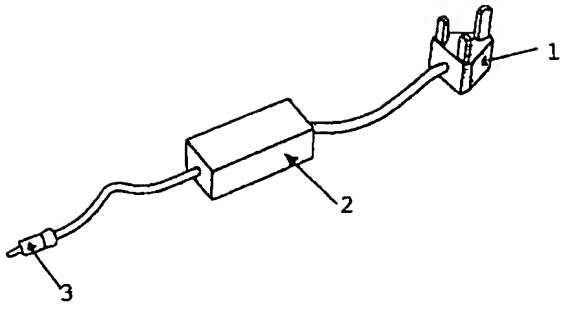

FIG. 1

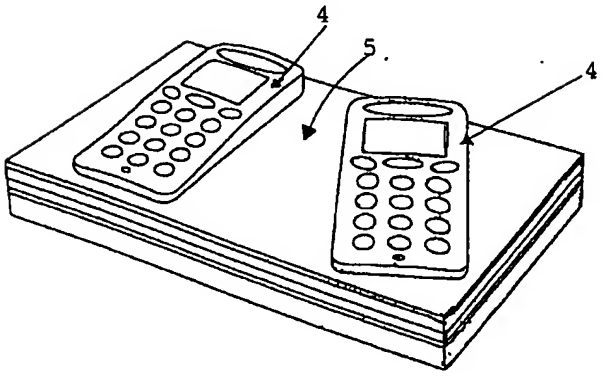

FIG. 2

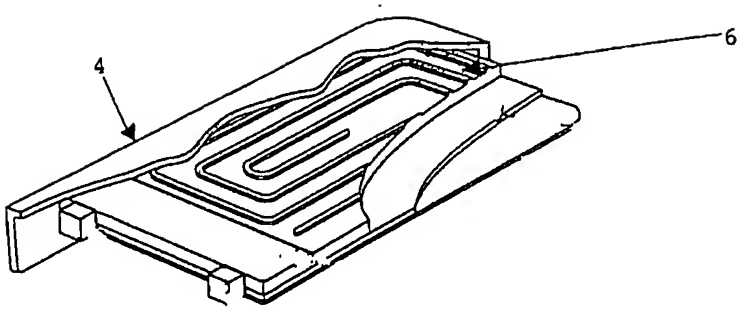

FIG. 3

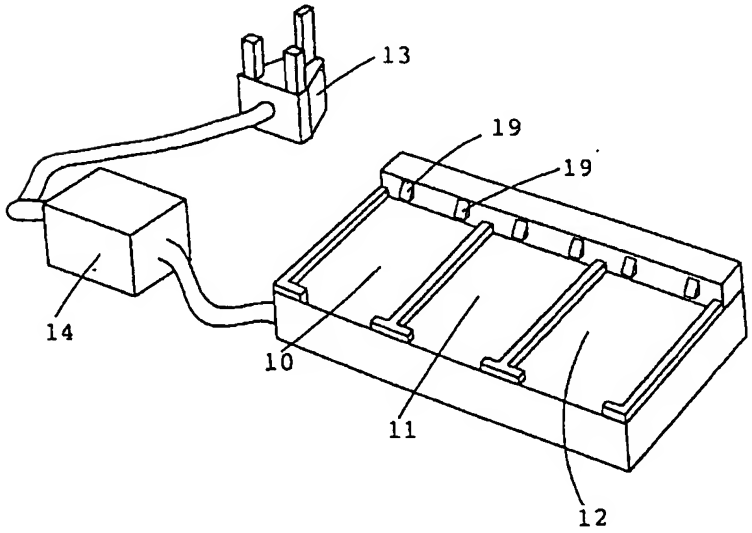

FIG. 4

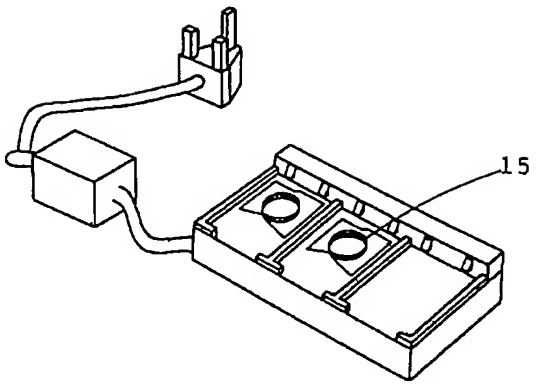

FIG. 5

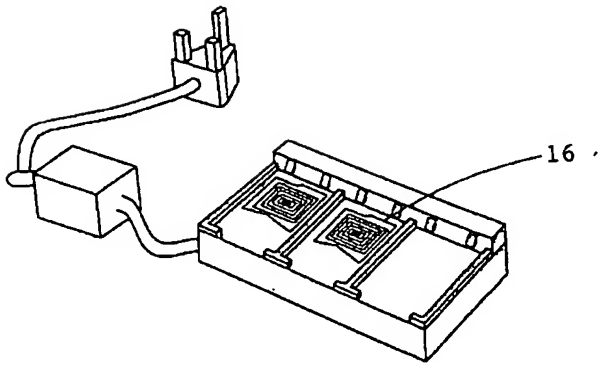

FIG. 6

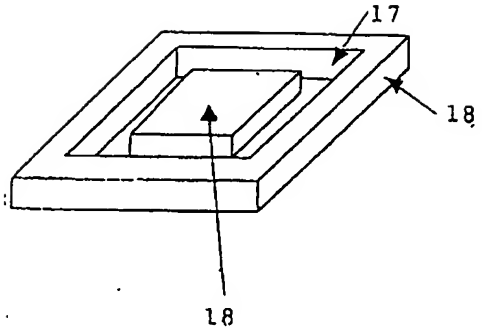

FIG. 7(a)

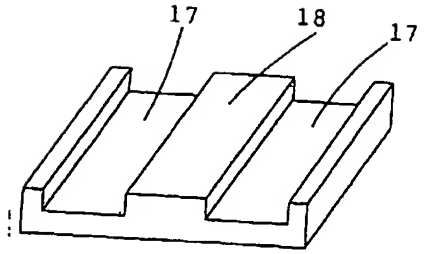

FIG. 7(b)

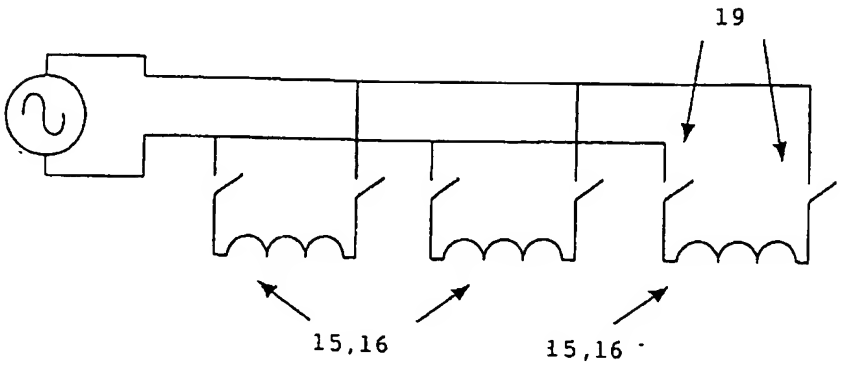

FIG. 8

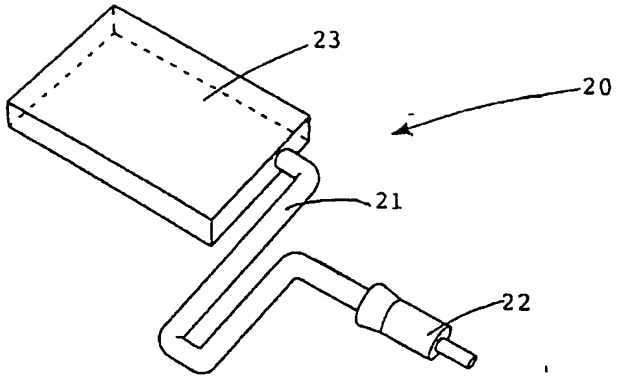

FIG. 9

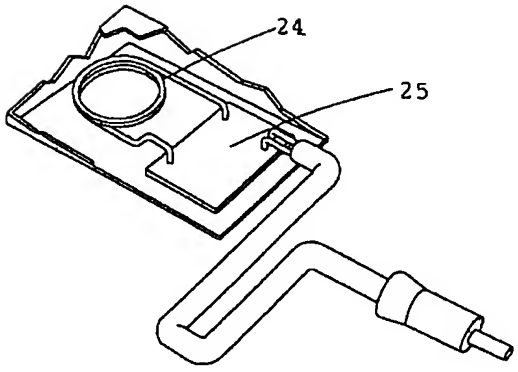

FIG. 10

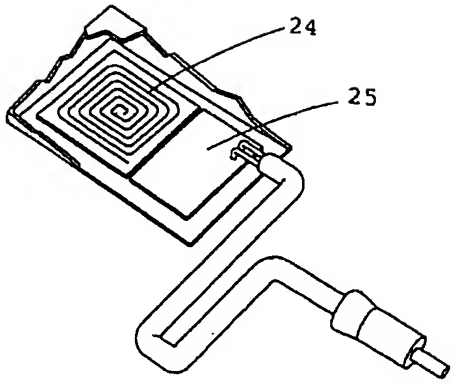

FIG. 11

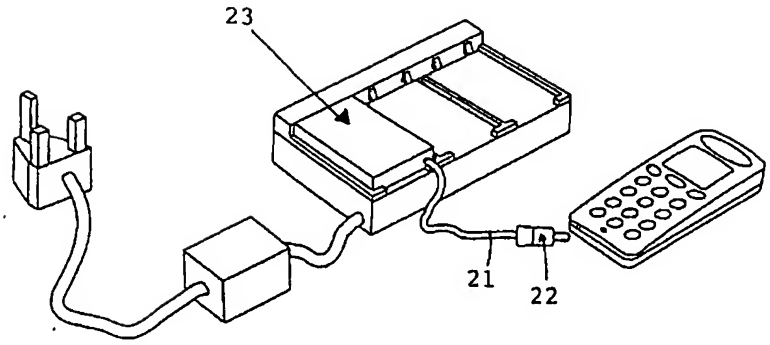

FIG. 12

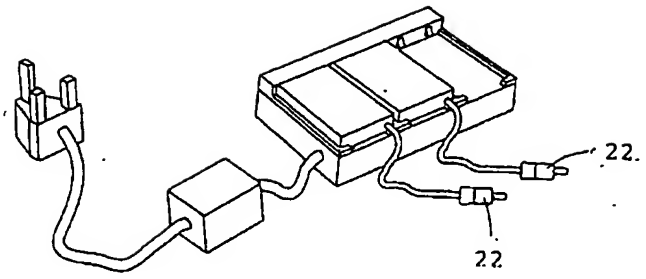

FIG. 13

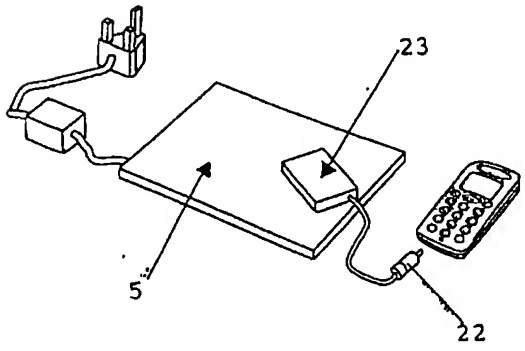

FIG. 14

2399466

BATTERY CHARGING SYSTEM

The present invention relates to apparatus for charging the batteries of items of portable electronic equipment, and in particular to such an apparatus that may be used to charge various devices having conventional charging circuitry.

Portable electronic equipment such as mobile phones, MP3 players, electronic dictionaries and handheld computing systems often use rechargeable batteries. Traditional charging systems employ an AC to DC power conversion circuit (such as a switch mode power supply or a step-down transformer followed by an AC to DC voltage regulator) to provide a DC voltage typically within the 3V to 24V range for charging the battery or batteries inside the portable electronic equipment through the conventional interface including a cable and connector in the battery charger and a charging socket in the portable equipment to be charged. Fig.1 illustrates a typical example of such a conventional charger comprising a plug 1 for connection to a mains socket, an AC-DC power conversion circuit contained within a housing 2, and a connector 3 for insertion into the charging socket of a conventional portable electronic device.

United Kingdom patent applications 0213374.2 and 0226893.6 describe an inductive charging platform that allows portable electronic equipment to be charged simply by placing the electronic equipment 4 on the charging platform 5 regardless of the orientation of the equipment position as shown in Fig.2. The inductive charging platform 5 includes a primary winding or windings that are excited by an AC voltage source, while the secondary winding and associated charging circuit are incorporated into the design of the portable equipment 4 to be charged as shown in Fig.3. However, one limitation of the

charging platform described in UK patent applications 0213374.2 and 0226893.6 is that the charging platform is not compatible with conventional electronic equipment that uses a conventional charger and can only be used with electronic equipment that is designed to work with the charging platform. An object of the present invention is to provide a solution that makes the charging platform described in UK patent applications 0213374.2 and 0226893.6 compatible with conventional portable electronic equipment.

According to the present invention there is provided a battery charging system comprising a primary module and at least one secondary module, said primary module comprising means for connecting to a mains supply, and at least one primary winding adjacent to a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent to a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

According to another aspect the invention also extends to a secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

Some embodiments of the present invention will now be described with reference to the accompanying drawings, in which:-

Fig.1 shows a conventional battery charger,

Fig.2 illustrates the inductive battery charging system of UK patent applications 0213374.2 and 0226893.6,

Fig.3 illustrates the integration of the secondary winding in the portable equipment in the system of UK patent applications 0213374.2 and 0226893.6,

Fig.4 illustrates a battery charging system according to an embodiment of the invention,

Fig.5 is a view similar to Fig.4 but part broken away to show the primary winding,

Fig.6 is a view similar to Fig.5 but of an alternate embodiment,

Figs.7(a) and (b) illustrate possible magnetic cores for use in the embodiment of Fig.5,

Fig.8 shows an equivalent circuit for the charging system of an embodiment of the invention,

Fig.9 illustrates an example of a secondary module for use in an embodiment of the invention,

Fig.10 shows a part broken away view of secondary module of a first embodiment of the invention,

Fig.11 is a view similar to Fig.10 but of a second embodiment,

Fig.12 is a view showing the complete charging system according to an embodiment of the invention,

Fig.13 is a view similar to Fig.12 but showing how the charging system according to an embodiment of the invention can be used to charge multiple devices having different forms of charging connections, and

Fig.14 is a view illustrating how an embodiment of the present invention can be used to enable a conventional electronic device to be charged using an inductive charging platform.

The inductive battery charging platform proposed in UK patent applications 0213374.2 and 0226893.6 (Fig.2), which can be regarded as the primary circuit of a transformer system (or the primary inductive charging system), can be used as a standard battery charging platform for portable electronic equipment with compatible inbuilt secondary circuitry in the electronic equipment to be charged. However, existing electronic equipment that is not designed for compatibility with the battery charging platform cannot take advantage of the convenience offered by the battery charging platform. The present invention, at least in its preferred forms, provides both a battery charging system that can stand independently and can be used to charge existing conventional devices, and a means by which a conventional electronic device can be charged using the charging platform of UK patent application 0213374.2 and 0226893.6.

Referring firstly to Fig.4 there is shown therein a perspective view of a part of a battery charging system according to an embodiment of the present invention. The part of the charging system shown in Fig.4 may be termed the primary inductive charging system since as will be explained below it comprises at least one primary winding. The part of the battery charging system shown in Fig.4 may also be considered to be an extension system since in preferred forms it may be adapted to charge multiple devices

and is therefore analogous to a conventional extension lead that allows multiple items of electronic equipment to share the same power socket.

The charging system is provided with multiple charging slots 10,11,12 for receiving secondary charging modules to be described further below. As will be explained further below each charging slot is provided with a primary winding. Fig.4 shows a schematic of the primary inductive charging extension system with three charging slots. However, it should be noted that the number of slots is not restricted to three and can be as few as a single charging slot, or can be more than three. It will be understood that the number of charging slots dictate the number of devices that can be charged simultaneously. The primary charging extension system is connected to the mains through a plug 13 and includes a power electronic circuit 14 that provides a high-frequency (typically in the range of 1kHz to 2MHz) AC voltage to the primary windings that are located under the charging slot surfaces. It should be noted that the surfaces of the slots are flat and the slots are separated from each other by dividing walls. Each slot is therefore the same size as the surface of a housing of a secondary module to be described below, and the separating walls and mechanical switches to be described below together act to engage a secondary module and hold it in a correct orientation for efficient charging.

Each primary winding can be a coil 15 as shown in Fig.5 or a printed-circuit-board (PCB) winding 16 as shown in Fig.6. If the primary winding is a coil 15, the coil 15 is preferably accommodated in a space 17 defined by a magnetic structure 18 such as the two examples shown in Fig.7(a) and (b) in which the coil is wound around a magnetic core 18. If a PCB winding is used, appropriate electromagnetic (EM) shielding, such as

the combined use of ferrite and copper sheets described in US 6501364, can be placed under the PCB winding in order to ensure that the magnetic flux generated in the PCB winding will not penetrate through the base of the primary inductive charging extension system. Preferably, mechanical switches 19 can be provided in each charging slot that when closed activate the primary winding to the high-frequency AC voltage source when the secondary charging module (to be described below) is inserted in that particular slot. As discussed above, the mechanical switches may also serve to engage and hold the secondary module in place. This mechanism ensures that only windings in the slots used by the secondary modules are excited by the high-frequency AC voltage source. The equivalent circuit is shown in Fig.8.

Fig.9 shows a typical secondary charging module 20 for use with the primary charging extension system shown in Fig.4. Each secondary module has a conventional cable 21 and charger connecter 22 that is adapted to be received within the charging socket of a conventional electronic device. It will be understood that different secondary charging modules 20 may be provided differing only by the type of the connector 22. Each secondary charging module 20 is provided with a housing 23 that contains a secondary circuit to be described below. The housing is preferably rectangular (but of course could be any suitable shape) and of such a size that it may be received in one of the slots 10-12 of the primary charging extension system. The housing 23 should have at least one preferably flat surface for placing on the charging slot of the primary charging extension system. This flat surface is preferably parallel to the plane of the secondary winding within the housing such that when the secondary module is placed in a slot of the primary extension system the secondary winding is substantially parallel to the primary

winding beneath the surface of the slot. The housing 23 of the secondary module should preferably be made of non-conductive and non-ferromagnetic material so that no current will be induced in the housing material.

As can be seen from Figs.10 and 11 inside each secondary charging module 20 are at least one secondary winding 24 and charger circuitry 25 that receives the induced AC voltage in the secondary winding and provides a regulated DC output voltage for the charging purpose. The secondary winding should be kept inside the housing. The secondary winding can be a coil (Fig.10) or it can be printed on a PCB (Fig.11). The function of the secondary winding is to act as the secondary winding of a transformer system to pick up the changing magnetic flux generated by the primary winding of the primary charging extension system.

The secondary coil or PCB winding should be placed close to the (preferably flat) surface of the housing of the secondary charging module so as to pick up maximum changing AC magnetic flux from the primary inductive charging extension system or platform. According to Faraday's Law, an AC voltage will be induced across the secondary winding if the secondary winding senses a changing magnetic flux (that can be generated by the primary winding in the primary inductive charging system).

The terminals of the secondary winding are connected to the input terminals of an electronic circuit 25 that (1) performs the AC-DC power conversion function (i.e. rectifying the AC voltage into DC) and (2) preferably also regulate the DC voltage to a desired value (typically in the range from 3V to 24V) within a certain tolerance. Through a cable and a charger connector for connecting to charging socket in the portable

equipment, this DC voltage can be used to charge the portable equipment a shown in Fig.12.

The secondary winding design (such as number of turns and dimensions of windings), the DC regulated voltage level and the type of connector can be designed according to the charging requirements of specific electronic products. Therefore, different secondary charging modules can be designed for different ranges of products, but all secondary modules are compatible with the same primary charging extension system as shown in Fig.13 in which two different types of secondary modules adapted for charging different devices and having different connectors 22,22' are shown in adjacent slots of the primary charging extension system. As the primary inductive charging extension system preferably has several charging slots for accommodating the secondary charging modules, it can be used to charge several items of conventional portable electronic equipment simultaneously.

A further advantage of the secondary charging module is that it allows a conventional electronic device to be charged using the inductive battery charging platform described in UK patent applications 0213374.2 and 0226893.6. Although a conventional electronic device cannot be charged by placing it directly on the charging platform surface because it does not have the in-built secondary winding, instead a secondary charging module can be placed in the inductive charging system and charge the conventional device therefrom as shown in Fig.14

In principle, the housing of the secondary charging module can have more than one preferably flat interface surface. If the housing is a cuboid it will have two large opposed interface surfaces (eg upper and lower surfaces of a relatively thin flat cuboid

structure a shown in the Figures) and with this cuboid design, either interface surface of the secondary module housing can be placed on the charging slots of the primary inductive charging extension system or other charging platform. This cuboid design makes the secondary charging modules very user-friendly because it does not matter which way up the housing of the secondary module is placed on the primary charging surface.

In summary, a preferred embodiment of the secondary charging module consists of a

(i) a non-conductive housing that has at least one surface (and preferably two surfaces) for placing on the charging slot of the primary charging extension system or the charging platform of UK 0213374.2 and that accommodates the secondary winding and circuitry for charging the electronic equipment,

(ii) A secondary winding, that can either be printed in a printed-circuit-board (PCB) or a conductor coil,

(iii) an AC-DC power conversion circuit that converts the ac induced voltage picked by the secondary winding from the primary AC voltage excitation into a regulated or unregulated DC voltage, typically in the range from 3V to 24V,

(iv) a conventional cable that connects the DC voltage output of the secondary circuitry to a connector that is compatible with the charging socket in the conventional electronic equipment.

It will thus be seen that, at least in preferred forms, the charging system of the present invention including the proposed secondary charging modules offers users a convenient and user-friendly battery charging system for a wide range of portable electronic equipment. Using the appropriate charger connectors that are compatible with

different portable equipment, the proposed charging system enables one single charging system (that occupies only one power point or socket in the ac mains) to charge a wide range of electronic equipment.

CLAIMS

1. A battery charging system comprising a primary module and at least one secondary module, said primary module comprising means for connecting to a mains supply, and at least one primary winding adjacent a charging surface of said primary module, and wherein said secondary module comprises a secondary winding adjacent a surface of said secondary module, circuit means for converting alternating current generated in said secondary winding to a regulated DC output, and a charging connector for connection to the charging socket of an electronic device.

2. A battery charging system as claimed in claim 1 wherein said primary charging module comprises a plurality of primary windings each associated with a respective charging surface whereby said primary charging module is able to receive a plurality of secondary charging modules simultaneously.

3. A battery charging system as claimed in claim 2 wherein said charging surfaces are provided with engagement means for engaging a secondary module.

4. A battery charging system as claimed in claim 3 wherein said engagement means include a mechanical switch whereby power is supplied to said primary winding only when a secondary module is engaged by a charging surface.

5. A battery charging system as claimed in claim 1 wherein said primary winding is formed by a coil.

6. A battery charging system as claimed in claim 5 wherein said coil is wound on a magnetic structure.

7. A battery charging system as claimed in claim 5 wherein said coil is parallel to said charging surface.

8. A battery charging system as claimed in claim 1 wherein said primary winding is printed in a printed circuit board.

9. A battery charging system as claimed in claim 8 wherein said printed circuit board is parallel to said charging surface.

10. A battery charging system as claimed in claim 1 wherein said secondary winding is formed by a coil.

11. A battery charging system as claimed in claim 10 wherein said coil is parallel to said charging surface.

12. A battery charging system as claimed in claim 1 wherein said secondary winding is printed on a printed circuit board.

13. A battery charging system as claimed in claim 12 wherein said printed circuit board is parallel to said charging surface.

14. A secondary module for a battery charging system, comprising: a housing having at least one charging surface, a winding provided in said housing adjacent to said surface and adapted to receive magnetic flux when said surface is brought adjacent to a primary winding, circuit means for converting alternating current in said secondary winding to a regulated DC output, and a connector means for connecting said DC output to the charging socket of an electronic device.

Application No:	GB 0305428.5	**Examiner:**	Peter Keefe
Claims searched:	1–14	**Date of search:**	23 October 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A		US 5959433 A CENTURION column 1 lines 28–44

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC[V]

H2H

Worldwide search of patent documents classified in the following areas of the IPC[7].

H02J

The following online and other databases have been used in the preparation of this search report:

WPI, PAJ, EPODOC